Title	Conceptualisation of an intelligent salutogenic room environment
Authors	Dalton, Cathy;Harrison, J. D.
Publication date	2012-04-11
Original Citation	Dalton, C. and Harrison, J. D. (2012) 'Conceptualisation of an intelligent salutogenic room Environment', in Breedon, P. (ed.) Smart Design. London: Springer-Verlag, pp. 87-95. doi: 10.1007/978-1-4471-2975-2_10
Type of publication	Book chapter
Link to publisher's version	https://www.springer.com/gp/book/9781447129745 - 10.1007/978-1-4471-2975-2_10
Rights	© 2012, Springer-Verlag. All rights reserved.
Download date	2025-06-10 04:48:46
Item downloaded from	https://hdl.handle.net/10468/8004

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Conceptualisation of an intelligent salutogenic room environment

Dalton C., Harrison J.D., Cork Centre for Architectural Education, Ireland.

Abstract

Human functioning in the built environment is affected by the degree of "fit" or congruence between a user and her/his surroundings.[1, 2] By extension, the culture of care-giving and physical environment of care settings are inextricably linked. This conceptual model, developed in the context of the MyRoom project,[3] is based on analysis of prerequisites for psychosocial congruence, drawn from theories of environmental psychology [4, 5], and from the evidence-base. [6]The model examines how these requirements may be addressed through architectural design enhanced by ubiquitous affective computing, integrated into the built environment, to maximise person-environment fit in healthcare settings. Where specific user needs, arising from cognitive and physical impairment associated with ageing and dementia, are not fully met by the built environment, these needs may be addressed through affective computing. This is to be achieved by means of real-time processing of data from an integrated system of Body Sensor Networks and Room Sensor Networks. This paper describes in detail an adaptive salutogenic single-user room in an elderly care setting, as a template of how an environment responsive to a user's physical and emotional state might be realised, promoting *salutogenesis* [7] through optimal congruence. Psychosocial congruence, on which this paper focuses, is enhanced through actuation of multisensory applications designed to provide appropriate stimulation. Recent research on affective computing for children with ASD may be translational.[8] [9] A majority of elderly persons in residential care have some form of dementia[10]. This implies that design of residential care and dementia care environments for elderly people is effectively inseparable. Architecture, further enhanced by ambient technologies, has the capacity to act as a major, and timely catalyst for a radical re-thinking of the culture and environment of care.

Introduction

The context of the aging demographic in Western society, and the consequent requirement for provision of suitable environments, including residential care, for an increasing number of older people with dementia forms a backdrop to the research.

Human behaviour takes place in physical settings that influence behaviour and functioning in complex and sometimes unexpected ways. All buildings affect their users, whether intentionally or not. Environment affects not only physical and functional tasks, but also psychological and social processes, ranging from performance on cognitive tasks to emotional well-being. [6] Good design is conscious of its power to exert such influence, and uses it carefully. Stress, including stress arising from deficits in environmental fit, is recognised as a contributor to both psychological and physical illness[11], including Alzheimer's Disease (AD), where it has been found to be linked both to onset and progression. Research has indicated that stress is related to the onset of dementia-related neural changes, [12], and that cortisol has a particular significance. [13]. This may explain the greater prevalence of AD in people with depression or increased levels of anxiety. [14] An environment designed to minimise and alleviate inappropriate stress is therefore an essential prerequisite for elderly care. This paper provides a detailed framework for design of a single, own-room setting congruent with the needs of an elderly user, in a residential setting. Theories of congruence, or environmental fit, have been summarised in a previous paper [15] setting out basic principles for design of an intelligent and responsive healthcare environment. A successful environment supports not only survival needs and instrumental tasks, but also psycho-social functioning[4].

Adaptive architecture has to date almost exclusively involved adaptation to environmental variables, frequently through kinetic structures. Other adaptations in architectural contexts, created in response to human presence or activity, are often conceived of solely as creative interventions or performance art. This model proposes an alternative adaptive architecture, enabled by embedded wireless sensoring networks, which through them becomes responsive, in real time, to an individual user's emotional and physical state. Direct kinetic response to physiological data has been tentatively researched in ExoBuilding. [16] In the context of architectural theory, the MyRoom proposal represents not only an extension of theories of responsive architecture as described by Nicholas Negroponte[17], but a fusion of research in affective computing and responsive environments, creating a new paradigm for user-centred responsive architecture, generalizable to all building types. In the MyRoom model, physical characteristics such as lighting, temperature, colour and images are altered to provide a constantly variable environment best suited to an individual's needs at a given time. However, it is in care settings, where users are likely to have some degree of physical and/or cognitive impairment, where this approach stands to deliver the greatest benefits. The increasing proportion of elderly people, and the inevitable increase in incidence of dementia provides an impetus to conceive a new type of responsive architecture that supports and maximises independent functioning and quality of life for older people. The following recommendations on design of a salutogenic single-room environment are derived from Heerwagen's summary of attributes of buildings which are supportive of wellbeing needs.[18] [2] In the proposed model, integrated sensor networks are used to enhance those attributes.

The restorative capacity of natural environments is well–documented [19] [20]; how design can replicate this requires detailed consideration. *Connection to nature and natural processes* can be facilitated in a number of ways. The most obvious means in the design of a resident's room is through carefully considered design a placing of windows, to optimise views and natural light. Cill heights, relationships to external spaces and resulting available views, position and type of external planting, and internal room layout all should be given detailed consideration. The physical characteristics of the user must also be taken into account: an older person in care may have restricted mobility or be confined to bed or a seated position for long periods. Seasonal changes may negatively, as well as positively affect external views available from a single room. There is therefore a significant case for provision of natural forms or imagery within the room, to complement availability of external views of nature. This model proposes that these be provided as multimedia applications based on natural images, initiated in response to indications of stressed states, or designed to provide stimulus when appropriate.

Physical access to external spaces can also provide contact with nature, and is commonly provided from communal areas in care settings. The possibility of direct physical access to outdoors from an individual resident's room should be considered, and may be afforded if the external space is suitably configured and secure. This is still uncommon in residential care design, though single-storey buildings are the norm in many countries (Ireland, UK, US). Access might be provided via "protected" personal space, e.g. a small patio/ paved area with seating. In a multi-storey building (common in continental Europe) a balcony or winter garden may be provided. The provision of such access also increases freedom of individual choice and supports a variety of situations. Again, a frail elderly user's physical status may mitigate against independent or spontaneous use of such access, particularly during inclement weather.

Provision of external views coupled with a variable internal environment also support needs for *sensory change and variability*. An individual room will of necessity have a fixed, often single orientation. This affects both quantity and quality (brightness, colour) of daylight entering, and can contribute to sensory variability. Not all individual rooms will enjoy an ideal orientation. In domestic design, in temperate latitudes, it is common to locate rooms so as to benefit from natural light at those times of day when the space is most used, e.g living areas face south and south-west, while bedrooms face east. While communal spaces in residential care settings are often located to benefit from orientation, the same priority may not be applied to resident rooms, though they often provide the only available personal space for relaxation, privacy and self-actualization. The requirements for orienting a single space to suit all desirable activities can conflict. In the preferred domestic-scale care setting, orientation will be greatly influenced by a combination of siting and priority of function: in short, if communal spaces "get" the best aspect, bedrooms may be relegated to less favourable positions. Small-scale courtyard models, while secure, may prove restrictive in terms of orientation.

To support *behavioural choice and control*, the room must accommodate a variety of activities. This may require little more than adequate space provision. While Finnish residential care models provide residents with bed-sit type accommodation, as well as communal spaces, other models realistically allow only space for sleeping and grooming in the resident's own room; this is insufficient to meet needs for psycho-social congruence, as described. Though "household" type models are based on the scale and detail of domestic buildings, it should be borne in mind that the "household" is artificial: residents may have little choice about those with whom they cohabit. Where only shared spaces (e.g. dining and living-rooms) are available for socialisation, they do not provide the same levels of privacy as similar spaces in one's own home: it is not always possible to predict or control who else may be sharing that space. Visitors' rooms are often a sort of "no-man's land"; they can be impersonal, and not conducive to informal socialisation. Ability to socialise is influenced by availability of designed as well as unintended places to meet[21] [22]. Environment governs not only opportunities for socialisation but also types of socialisation facilitated: the level of privacy in a physical setting affects degree of disclosure in conversation, and the level of intimacy achievable. The resident's own room therefore takes on additional significance as a potential location for more intimate socialisation, for example with family, or for meeting carers or clinicians in a familiar and reassuring environment. By the same token, it may also afford space for privacy, relaxation and psychological restoration. If suitable space for such activities is not available, this will inevitably impact negatively on well-being. The scenario of bedroom doors left constantly open, on the basis that residents require constant observation, is commonplace. Sensoring allows the possibility of carers monitoring user status remotely, with processed sensor data streamed to a carer's pc, or made available on a "virtual" window immediately outside the room, without the necessity for a direct line of sight. The latter approach is also suited to acute care rooms, where it might replace an observation window, which places a patient continuously "on view". The fundamental prerequisite to support a variety of activities is sufficient space allocation: it is not possible to provide for all these needs while limited by areas defined by many contemporary care standards. On analysis, they are insufficient to support wellbeing needs, as they inevitably limit the environmental support achievable. Lack of space will inevitably result in activities being supported only in a limited or predetermined form, no matter how well-designed the context.

The possibility of multiple room uses can be supported by a variable internal environment, including artificial lighting designed for both functional and psychosocial needs. "Cycled lighting" can support circadian rhythms[23]; blue-green light therapy is effective for both seasonal and non-seasonal depression [24], and light may also be used to minimise "sundowning" symptoms[25]. Lighting systems should have the ability to be automatically activated, to compensate for user impairment. Given the particular role of stress in relation to AD, activation of environmental changes which can assist in alleviating stressed states have particular potential for increasing wellbeing. A visual or multimedia application specifically designed to reduce stress, which is activated in response to biosignals indicative of

an inappropriately stressed state in an individual user, will also have the effect of externalising a user's emotional state, and may thus also potentially promote self-awareness, as well as de-stressing, not only by exposure to the imagery but also as a consequence of biofeedback[26], and clearly communicating that internal emotional state to an observer or carer. This is particularly valuable in the case of a resident who has lost the ability to verbalise, as is characteristic in AD.

Opportunity for regular exercise is catered for by provision of secure, easily-accessible external spaces; prompts for use might be incorporated in the room environment. Social support and sense of community are largely catered for outside the scope of an individual's room, though the room can provide space for some types of socialisation, as described above, and should facilitate personalisation, including use of a resident's own furniture, and choice of decoration.

Principles for interventions in environments for elderly people with dementia

Corcoran and Gitlin [27] developed a series of principles for interventions in environments for elderly people with dementia (PWD), providing a framework based on manipulation of the environment to match environmental press[28] with user competence. These principles are applied here to application and interface design. Reduced competence renders a person with dementia more vulnerable to environmental influences, with ensuing increased stress.

Availability [1] refers to accessibility of objects in an environment. Clutter should be avoided, and an individual presented with familiar objects specific to the task in hand. Frail elderly people often create "control centres" in their living-space with useful objects close to hand, both visible and accessible. Reducing *complexity* offers accessible environmental information. This supports an argument for minimalism in interface design [29], and for a "Disappearing Computer"[30] approach, where applications, sensoring and associated networks are subsumed into a familiar physical context. *Flexibility* regarding use is not desirable: objects with one clear function are preferred; conversely, controls with multiple options should be avoided. Applications for easy access to personal data (music, photos, video) will have *Symbolic Meaning,* and help maintain self-identity**.** *Complexity* is related to the required skill level and number of steps needed to complete a task. Using an interface or application should be simplified or broken down into smaller steps to enable successful completion, and also designed so that only repetitive gross-motor activity is required [31, 32]. This suggests possible solutions to interface design, including simple gestural interfaces or large-scale, simplified touch-screen icons. Simplified, concrete verbal instruction might also be utilised. Supporting temporal orientation and reinforcing routine can facilitate user competence [32, 33]. In this context, provision of cycled lighting to reinforce circadian rhythms helps establish *temporal boundaries*. Seasonality might be reflected in lighting

---

[1] words in italics refer to principles identified in Corcoran and Gitlin 1991

and by varying the colour palette of visual applications. It has been suggested that as stressful situations accumulate as the day progresses, a person with dementia experiences a lowered stress threshold, which can lead to an increased likelihood of a "catastrophic reaction",[34]: aggressive outbursts, or restlessness associated with "sundowning". This might be countered by providing environmental cues for relaxation and restoration, including actuation of stress-relieving applications at intervals based on the user's own behaviour patterns. PWD commonly make mistakes, but may not recognise them, and may be upset by their consequences. Flexibility enabled by responsivity and automation can permit a user to safely explore how an environment operates, without rigid "rules". The possibility of making a "mistake" with negative consequences can be minimised through thoughtful design intervention: for example, taps could automatically switch off when water levels in a basin reach a specific level. Prompts for activities of daily living should be incorporated. An identified need for low-stimulus activity ("daydreaming"), necessary for defining and maintaining an individual's identity [35] might be supported by responsive actuation of applications e.g dimmed lighting, actuation of visual applications, personal digital data applications (photo albums, personal music collection).

Sensoring for use in care environments for elderly people

For longitudinal research on vulnerable subjects in live environments, current sensoring methods are often ethically unacceptable. EEG sensing, though it might provide invaluable data, is an example. The apparatus used, i.e. scalp electrodes, has changed little since its introduction over sixty years ago, and is unsuitable for use in long-term settings when, even in the limited context of a laboratory setting, it constitutes an additional stressor. In people with mid-stage dementia there is a significant likelihood of removal of any alien object, such as an identifiable wearable senor. The focus in development of wearable sensors for PWD must therefore focus on miniaturisation and unobtrusiveness. As most of the bulk of current sensors is made up of a battery-pack, an obvious research priority for wearables is development of smaller batteries, or of energy-harvesting technologies. While there has been considerable progress in terms of wearables, the term must be redefined in this context as a *non-contact sensor* which can be incorporated into the user's *own* clothing. This would seem to point towards sensors/ energy sources which are both thin *and* flexible, or highly-miniaturised, which may require specific collaborative research in the area of materials science. Recent research points to an alternative approach of using only room sensor networks, in response to the stated preferences of elderly users: in short, sensoring integrated into the built environment. [36, 37] Kinematic and PIR sensor data, and video analysis of facial recognition and posture/movement can all be used to infer emotional state, as in recent research into applications for children with Autism Spectrum Disorders (ASD)[8, 9]. For ASD subjects, research is investigating applications which infer emotional state from heart-rate, anticipating aggressive outbursts, where there is no warning sign in terms of verbalisation or change of facial expression (a feature

of ASD)[8]. It seems reasonable to infer that similar applications might be developed for PWD, to address inability to communicate, and response to stressed states, given the significance of stress in dementia.

Characteristics of a system enhancing congruence in a care setting

Advances in sensor technologies include increasing miniaturisation and development of non-contact bio-signal sensors. Coupled with development of more powerful and efficient wireless sensor networks, they support possibilities for intelligent adaptive ambient sensing networks. This model envisages responsivity through adaptation of an entire system over time to achieve optimal conditions for functional and psychosocial fit for an individual. As individuals respond differently to stress, any system designed to provide psychosocial support will need to "learn" what constitute optimal conditions for an individual, based on patterns of behaviour and observed responses to intervention. This approach also permits adaptation to progressive physical and cognitive decline, as system response to sensing will continually affect the underlying context/environment. Though complete autonomy is theoretically possible, direct input by users and carers may be incorporated to support needs for control. These inputs are of particular value in a set-up situation, until the basis for optimal conditions is established by machine-learning. System architecture will require integration of sensing data from which emotional affect can be inferred, including data modeling of complex behaviour and daily activities, and of the underlying physical context. Applications may be conceived of as prosthetic, designed to address compensation for specific cognitive and physical impairment. Constant and useful adaptation in response to data indicative of changes in the occupant's psychophysiological status and/or in ambient conditions, implies system intelligence, which will also need to take cognisance of interaction between network components. The model based on this template will be tested iteratively in a prototype currently being realised through collaboration with NEMBES[2] partners. Further research on applications and interfaces will focus on detailed examination of user interaction.

Ubiquitous	**-embedded in room fabric**
Affective	**-capable for inferring emotional state**
Minimalist	**- to minimise cognitive load on user**
Coherent	**- collaborative sensing, integrating bio-sensing data with contextual awareness**
Intelligent	**-capable for flexible reasoning to support complex ongoing decision-making, cognisant of component interactions**
Self-adapting	**-continually learning from occupant and context, to enable "best fit" for an individual, adjusting to changing user needs**

Table 1: Summary of proposed ICT system characteristics for enhancing environmental fit

---

[2] NEMBES is an inter-institutional multi-disciplinary research programme investigating a "whole system" approach to the design of networked embedded systems. www.nembes.org

References

[1] Kahana, E. (1982) A congruence model of person-environment interaction. *Aging and the environment: Theoretical approaches*, 97-121.

[2] Heerwagen, J. H., Heubach, J. G., Montgomery, J. and Weimer, W. C. (1995) Environmental design, work, and well being: managing occupational stress through changes in the workplace environment. *AAOHN J*, 43, 9, 458-468.

[3] Dalton, C. H., JD. (2010) MyRoom: A model for an intelligent salutogenic room prototype for an elderly user *Gerontechnology*, 9, 2, 206.

[4] Boyden, S. (1971) *Biological determinants of optimal health*. In The human biology of environmental change, ed. DJM Vorster. Conference proceedings, Blantyre, Malawi.

[5] Kaplan, S. (1983) A model of person-environment compatibility. *Environment and Behavior*, 15, 3, 311.

[6] Dilani, A. (2008) Psychosocially Supportive Design: A salutogenic approch to the design of the physical environment. *World Health Design*, July 2008.

[7] Antonovsky, A. (1987) The salutogenic perspective: toward a new view of health and illness. *Advances*. 4(1), S, 47-55

[8] Picard, R. W. (2009) Future affective technology for autism and emotion communication. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364, 1535, 3575-3584.

[9] Poh, M. Z., McDuff, D. J. and Picard, R. W. (2011) Advancements in Noncontact, Multiparameter Physiological Measurements Using a Webcam. *Biomedical Engineering, IEEE Transactions on*, 58, 1, 7-11.

[10] Torrington, J. (1996) *Care homes for older people*. Taylor & Francis.

[11] Antonovsky, A. (1996) The salutogenic model as a theory to guide health promotion. *Health Promot Int*, 11, 1.

[12] Osborne, F. X., Almeida at al (2011) Stress Acts Cumulatively to Precipitate Alzheimer's Disease-Like Tau Pathology and Cognitive Deficits. *Journal of Neuroscience*, 31, 21, 7840-7847.

[13] Davis KL, D. B., Greenwald BS, Mohs RC, Mathé AA, Johns CA, Horvath TB. (1986) Cortisol and Alzheimer's disease, I: Basal studies. *Am J Psychiatry*, 143, 3, 300-305.

[14] Wilson, R., Evans, D., Bienias, J., Mendes de Leon, C., Schneider, J. and Bennett, D. (2003) Proneness to psychological distress is associated with risk of Alzheimerís disease. *Neurology*, 61, 11, 1479.

[15] Dalton, C., Harrison, J.D. (2011) Designing an adaptive salutogenic care environment. In *Proceedings First International Conference on Adaptive Architecture,* London, forthcoming.

[16] Schnadelbach, H. (2011) Physiolocial Data in Adaptive Architecture. In *Proceedings of the First International Conference on Adaptive Architecture,* London, forthcoming.

[17] Negroponte, N. *Responsive Architecture*. In *Soft Architecture Machines.* (1975) MIT Press, Cambridge, Mass.

[18] Heerwagen, J. Investing In People: The Social Benefits of Sustainable Design. (2006) In *Proceedings of the Rethinking Sustainable Construction'06* Sarasota, FLA.

[19] Ulrich, R. S. (1979) Visual landscapes and psychological well-being. *Landscape research*, 4, 1, 17-23.

[20] Ulrich, R. S. (1984) View through a window may influence recovery from surgery. *Science*, 224, 4647, 420.

[21] Archea, J. (1977) The place of architectural factors in behavioral theories of privacy. *Journal of Social Issues*.

[22] Sundstrom, E., De Meuse, K. P. and Futrell, D. (1990) Work teams: Applications and effectiveness. *American Psychologist*, 45, 2, 120.

[23] Rea, M. S., Figueiro, M. G. and Bullough, J. D. (2002) Circadian photobiology: An emerging framework for lighting practice and research. *Lighting Research and Technology*, 34, 3, 177.

[24] Lee, T., Chan, C., Paterson, J., Janzen, H. and Blashko, C. (1997) Spectral properties of phototherapy for seasonal affective disorder: a meta analvsis. *Acta Psychiatrica Scandinavica*, 96, 2, 117-121.

[25] Mishima, K., Hishikawa, Y. and Okawa, M. (2001) Randomized, dim light controlled, crossover test of morning bright light therapy for rest-activity rhythm disorders in patients with vascular dementia and dementia of Alzheimer's type. *Chronobiology international*, 15, 6 1998), 647-654.

[26] Shi, X., Guo, Y., Nakagawa, Y., Morita, M., Uchiyama, H. and Fukomoto. I. A study of dementia rehabilitation BF system by light-stimulation. (2001) *Japanese Journal of Biofeedback Research*, 28, 79-87.

[27] Corcoran, M. and Gitlin, L. N. (1991) Environmental Influences on Behavior of the Elderly with Dementia. *Physical & Occupational Therapy in Geriatrics*, 9, 3-4, 5-22.

[28] Lawton, M. P. (1982) Competence, environmental press, and the adaptation of older people. *Aging and the environment: Theoretical approaches*, 33-59.

[29] Wren, C. R. and Reynolds, C. J. (2004) Minimalism in ubiquitous interface design. *Personal and Ubiquitous Computing*, 8, 5, 370-373.

[30] Streitz, N. and Nixon, P. (2005) The disappearing computer. *Communications of the ACM*, 48, 3, 33-35.

[31] Levy, L. L. (1987) Psychosocial intervention and dementia: I. State of the art, future directions. *Occupational therapy in mental health*.

[32] Berman, S. and Rappaport, M. B. (1985) Social Work and Alzheimer's Disease. *Social work in health care*, 10, 2, 53-70.

[33] Oakley, F. (1988) Clinical application of the model of human occupation in dementia of the Alzheimer's type. *Occupational therapy in mental health*, 7, 4, 37-50.

[34] Hall, G. and Buckwalter, K. (1987) Progressively lowered stress threshold: a conceptual model for care of adults with Alzheimer's disease. *Archives of Psychiatric Nursing*, 1, 6, 399.

[35] Rubinstein, R. L. (1989) The home environments of older people: A description of the psychosocial processes linking person to place. *J Gerontol*, 44, S45.

[36] Doyle, J., Bailey, C. and Dromey, B. (2009) Experiences of in-home evaluation of independent living technologies for older adults.

[37] Bakkes S, M. R., Kr¨ose B. (2011) Telemonitoring for Independently Living Elderly: Inventory of Needs & Requirements. In *Proceedings of Pervasive Health 2011*. Forthcoming.